Draft

Exponent

INTERNAL MEMORANDUM

TO: Joyce Tsuji

FROM: Lisa Yost

DATE: November 3, 1999

SUBJECT: Biomarkers for Arsenic Exposure

Several biological indicators of arsenic exposure, or biomarkers, have been used in researching groups of people exposed in the environment or in workplace settings. Biomarkers include arsenic measures in blood, urine, hair, or nails. Because arsenic is so readily cleared from the blood (e.g., a few hours), blood measurements are only useful for recent exposures and thus are not applied in evaluation of long-term, low-level environmental exposures (ATSDR 1998).

ATSDR has identified urinary measurements as the most reliable indicator of recent arsenic exposure because most arsenic absorbed through the lungs or gastrointestinal tract reaches the urine within 1 to 2 days (ATSDR 1998). Total arsenic concentrations in urine must be interpreted carefully to exclude arsenic from seafood, which contains relatively high concentrations of nontoxic organic arsenic forms (i.e., predominantly arsenobetaine). Research summarized here has either reported speciated arsenic (specifically inorganic or mono-dimethyarsenic forms) or used analytical methods that specifically exclude arsenobetaine. Arsenic in urine has been shown to increase with increasing exposure to arsenic in the air (Vahter et al. 1986; Yamamura and Yamauchi 1980; Yamauchi et al. 1989), in drinking water (Lin et al. 1998), and in soil (Hwang et al. 1997; Gebel et al. 1998; Hewitt et al. 1993).

Arsenic is also excreted from the body in hair and nails, although to a lesser extent than through urine. While urinary arsenic concentrations represent only absorbed arsenic, hair arsenic concentrations represent both external deposits on the hair and internal arsenic that was absorbed into the body and excreted through the hair (de Peyster and Silvers 1995; Hindmarsh 1998; Buchet et al. 1998). Arsenic that is deposited on hair cannot readily be washed off and cannot be distinguished from arsenic excreted from internal sources (Buchet et al. 1998).

Several of the researchers identified above who evaluated arsenic as a biomarker in urine also reported correlations between measurements of arsenic in hair and in soil (Gebel et al. 1998; Hewitt et al. 1993), air (Yamauchi et al. 1989; Yamamura and Yamauchi 1980), or water (Lin et al. 1998). Additional researchers have evaluated hair arsenic in comparison with measurements of airborne arsenic levels (de Peyster and Silvers 1995).

In populations exposed to arsenic in soil, both urinary and hair arsenic measurements were found to correlate with soil arsenic. However, urinary and hair measurements reported by Hewitt et al. (1993) did not correlate well with each other, which the authors reasoned might be due to externally deposited arsenic on hair. In contrast, Gebel et al. (1998) reported that 24-hour urinary arsenic measurements were correlated with scalp-hair arsenic and reported that the scalp-hair arsenic data confirmed the urinary arsenic data as a biomarker. Gebel et al. (1998), however, goes on to describe limitations in use of hair as a biomarker of internal exposure (i.e., absorbed arsenic), including the lack of standardization of scalp-hair data and the fact that hair color and the use of hair dyes and permanents affect hair arsenic measures. Gebel et al. (1998) then notes that:

> "The validity and quality of the data gained by scalp hair biomonitoring is not comparable to that gained by urine and blood biomonitoring."

The authors do note, however, that measurements of arsenic in hair provide a good means to compare arsenic exposure between one group and another.

Numerous other authors have evaluated the relative merits of urinary arsenic and scalp hair as biomarkers for arsenic exposure in various settings. de Peyster and Silvers (1995) evaluated use of hair arsenic as a biomarker of industrial exposures and noted the lack of standardization of normal hair arsenic concentrations and the inability to distinguish internal arsenic (i.e., arsenic that was absorbed into the body) from externally deposited arsenic as limitations in evaluating internal exposure. Similarly, evaluations of arsenic exposures via air (Yamamura and Yamauchi 1980) found much higher arsenic concentrations in hair measures than in urinary measures of exposure in workers exposed to arsenic trioxide in an industrial setting and reasoned that external adherence to hair accounted for this difference.

Hindmarsh (1998) reported that because arsenic from both internal and external sources is avidly bound to the outer surface of hair, external contamination can yield confusing results in evaluation of chronic arsenic exposure. He also noted that exposures may vary among hairs on a person and within the same strand of hair, and that samples should thus be taken from close to the scalp and from several sites on the head. Similarly, Buchet et al. (1998) reviewed data on biomarkers to evaluate their relative effectiveness in assessing exposure to inorganic arsenic and concluded that:

> Despite some encouraging reports, the use of arsenic levels in hair and nail as indices of internal does appear limited: efforts are needed to develop a standardized procedure to solve the problem of external contamination of samples.

Thus, while hair has been used as a biomarker in several settings, numerous authors have reported that urinary arsenic is a more reliable indicator of internal arsenic exposure.

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